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AIRS infrared polarization sensitivity and in-flight observations

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and
The AIRS Science Team

SPIE 5542-6
Denver, Colorado
August 4, 2004



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Agenda

- Introduction to AIRS Project
- AIRS Standard Products
- Polarization Sensitivity
- Response to Polarized Ocean Scene



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AIRS/AMSU/HSB Project Overview

Spacecraft:

EOS Aqua

Instruments:

**AIRS, AMSU, HSB,
CERES, AMSR-E**

Launch Date:

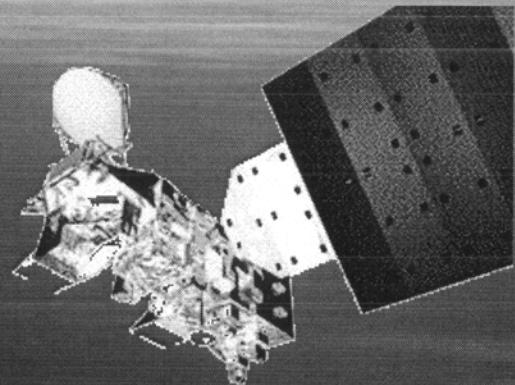
May 4, 2002

Launch Vehicle:

**Boeing Delta II
Intermediate ELV**

Mission Life:

5 years



AIRS Project Objectives

- 1. Improve Weather Forecasting:** AIRS data assimilated operationally by major NWP centers
- 2. Support Climate Modeling:** AIRS Water Vapor Profiles
- 3. Understanding Tropospheric Chemistry:** O₃, CO, CO₂, CH₄ + Others



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AIRS Science Team

Continuing Members

Chahine, M. (TL)	JPL
Aumann, H.	JPL
Gautier, C.	UCSB
Goldberg, M	NOAA/NESDIS
Kalnay, E.	UMD
LeMarshall, J.	JCSDA
McMillin, L.	NOAA/NESDIS
Revercomb, H	U of Wisconsin
Rosenkrantz, P.	MIT
Staelin, D.	MIT
Strow, L.	UMBC
Susskind, J.	GSFC

New Members

Brewster, K.	U of Oklahoma
Barker, D.	NCAR
Icano, M.	AER
McMillan, W.	UMBC
Atlas, R.	GSFC
Lord, S.	NOAA/NCEP
Barnet, C.	NOAA/NESDIS
Knuteson, R.	U of Wisconsin
Milosevich, L..	NCAR
Tobin, D.	U of Wisconsin
Mlynczak, M	LARC

International Partners

Chedin, A. (Continuing)	CNRS
Rizzi, R. (Continuing)	U of Bologna
Calheiros, R. (Continuing)	Brazil/HSB
McNally, T.	ECMWF
Saunders, R.	UKMO



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AIRS/AMSU/HSB Standard Products

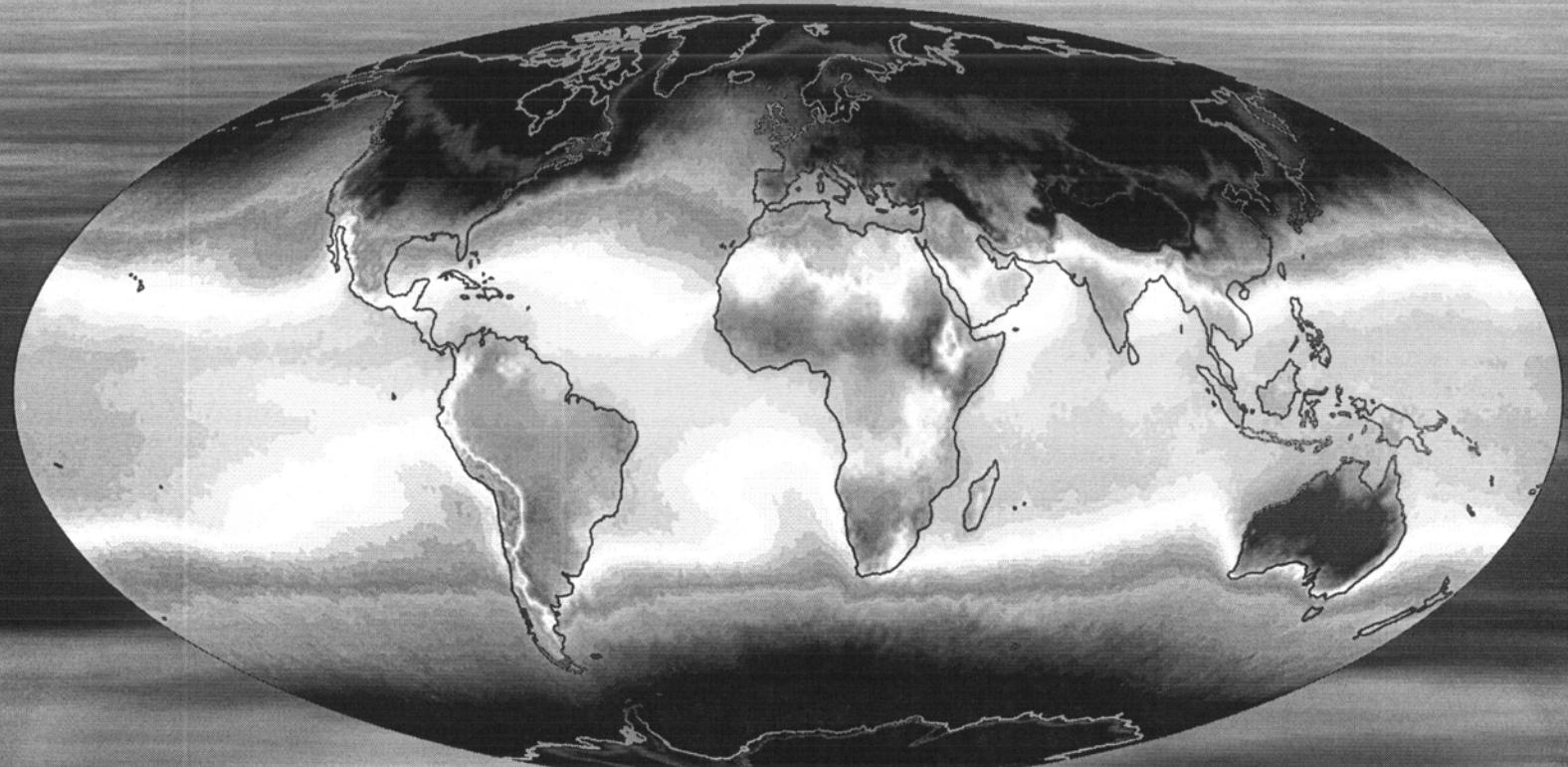
<u>Radiance Products (Level 1B)</u>	<u>RMS Uncertainty</u>	<u>Horizontal Resolution</u>
AIRS IR Radiance	3%*	15 x 15 km
AIRS VIS/NIR Radiance	20%	2.3 x 2.3 km
AMSU Radiance	0.25-1.2 K	45 x 45 km
HSB Radiance	1.0-1.2 K	15 x 15 km
<u>Standard Core Products (Level 2)</u>		
Cloud Cleared IR Radiance	1.0K	45 x 45 km
Sea Surface Temperature	0.5K	45 x 45 km
Land Surface Temperature	1.0K	45 x 45 km
Temperature Profile	1K	45 x 45 km
Humidity Profile	15%	45 x 45 km
Total Precipitable Water	5%	45 x 45 km
Fractional Cloud Cover	5%	45 x 45 km
Cloud Top Height	0.5 km	45 x 45 km
Cloud Top Temperature	1.0 K	45 x 45 km

*Absolute Relative to NIST



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AIRS Surface Air Temperature (January 2003)



Degrees Kelvin

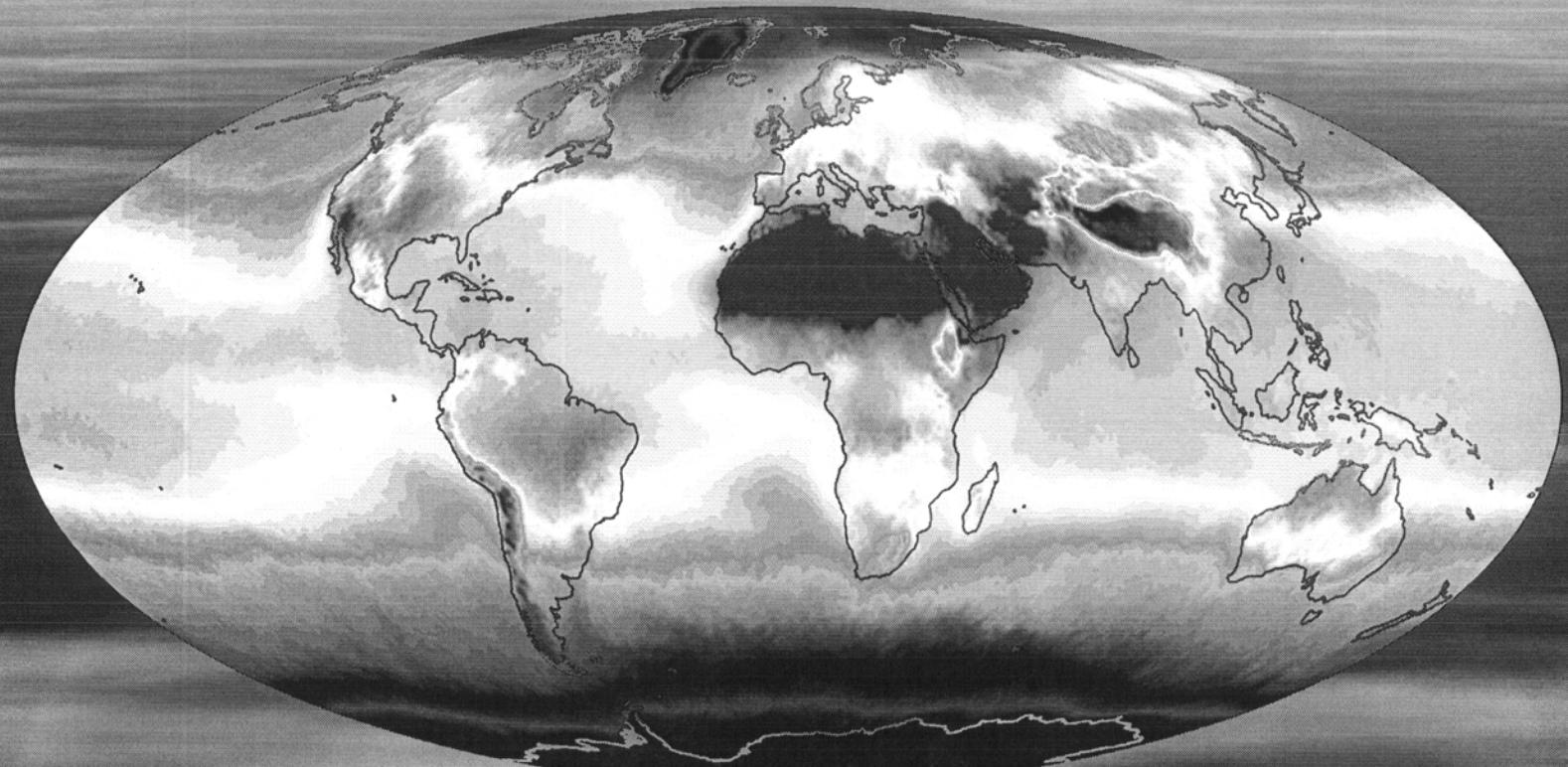
263 273 283 293 303



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AIRS Surface Air Temperature (July 2003)



Degrees Kelvin

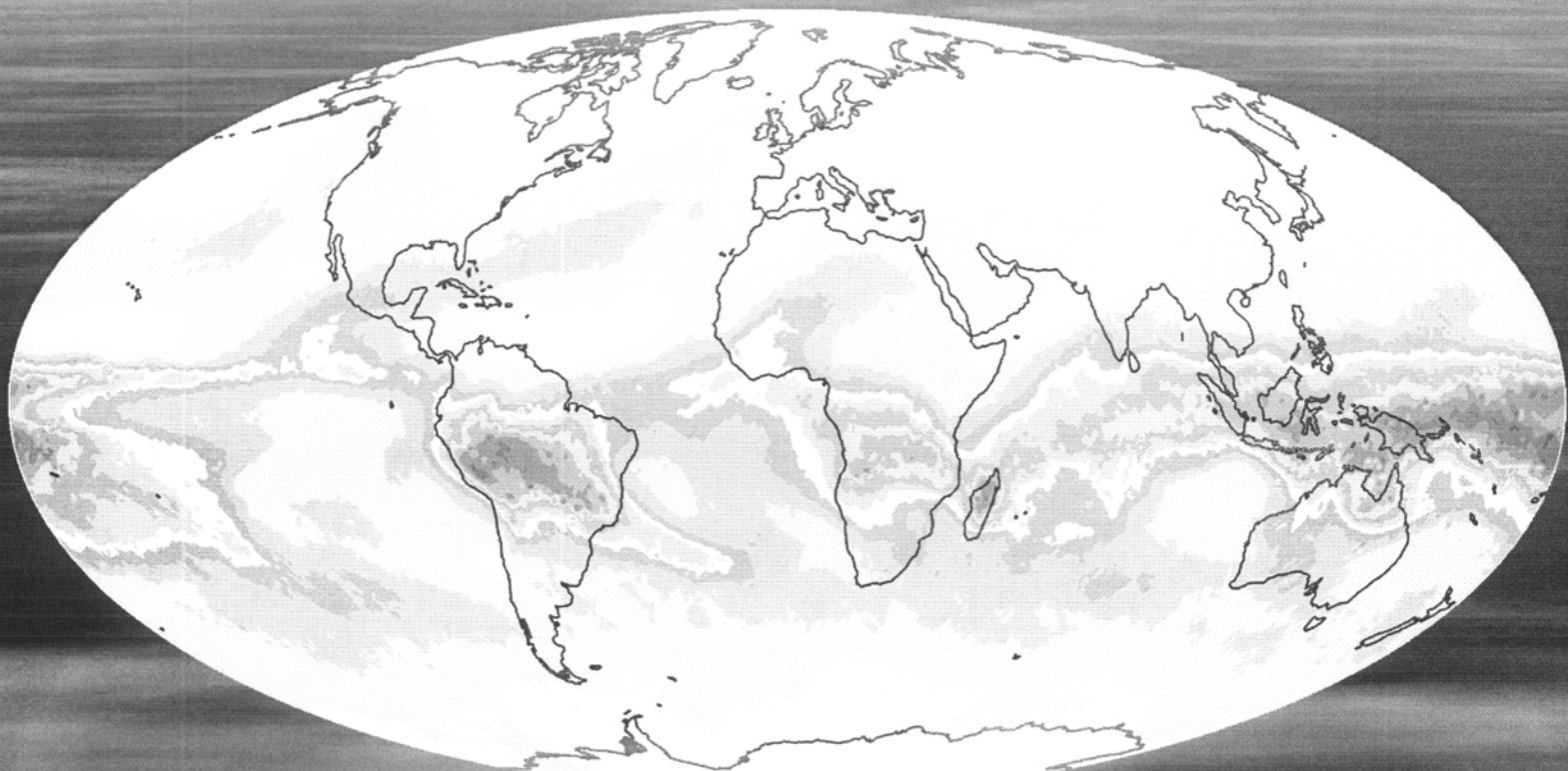




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AIRS Upper Atmospheric Water Vapor (January 2003)

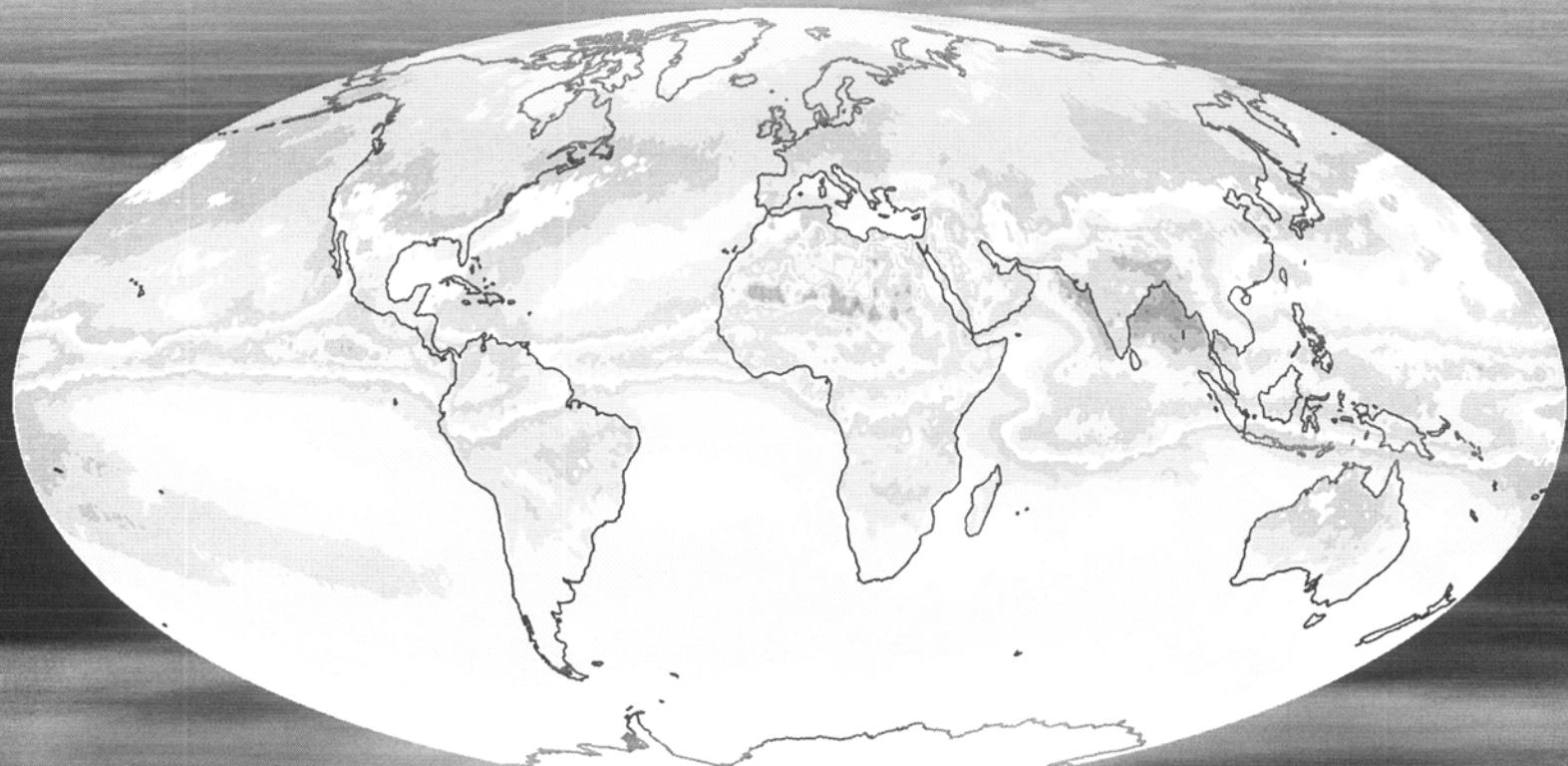




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AIRS Upper Atmospheric Water Vapor (July 2003)



Millimeters





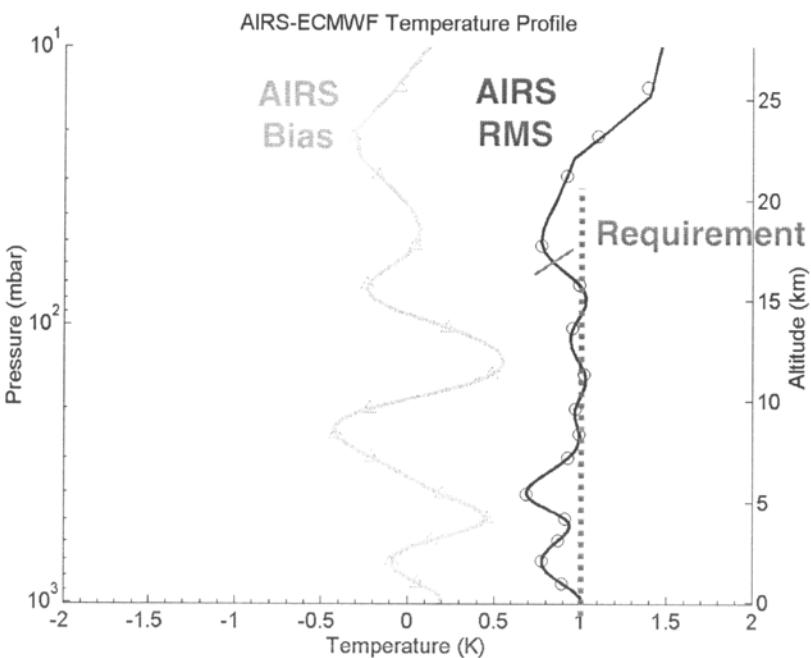
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AIRS Shows High Vertical Accuracy and Horizontal Resolution of Temperatures

Temperature Profiles Accurate to 1K/km to 30 mb

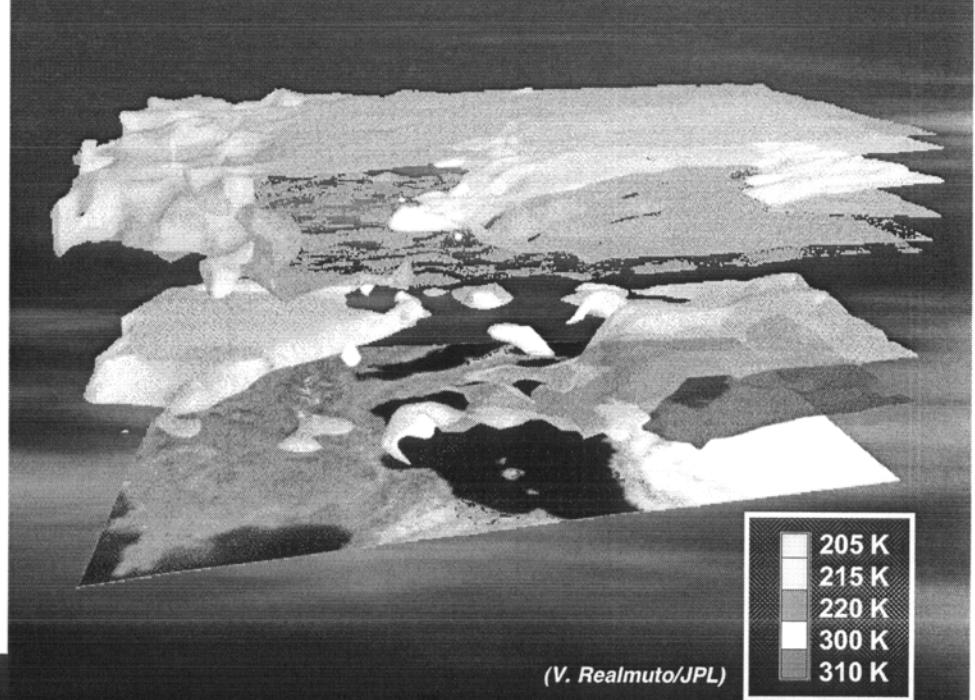
Ocean, Mid Latitude vs ECMWF



(T. Hearty/JPL)

Isotherms Show Good Horizontal Resolution

September 8, 2003



(V. Realmuto/JPL)



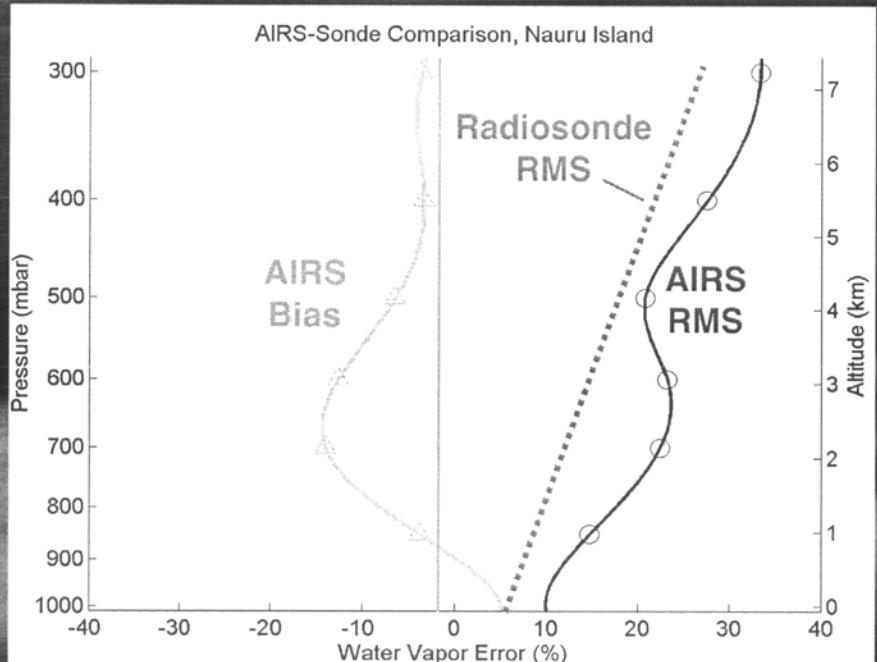
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AIRS Shows High Accuracy and Horizontal Resolution of Water Vapor

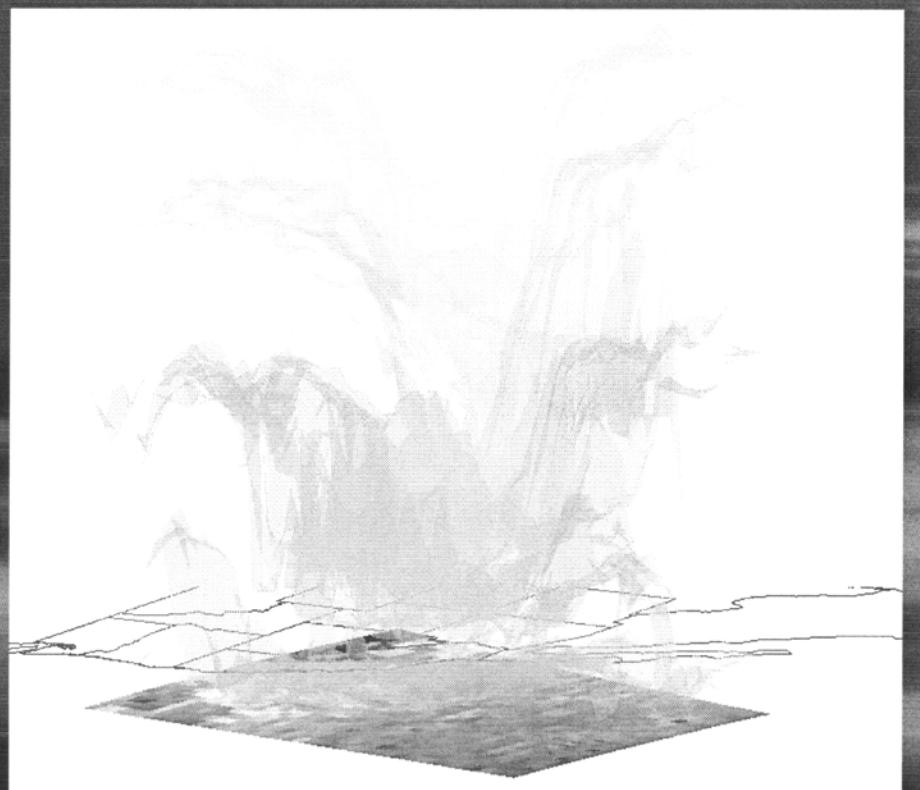
Water Vapor Profiles Match Radiosondes

Nauru Island Radiosondes



(E. Fetzer/JPL)

Isohyets Show Good Horizontal Resolution



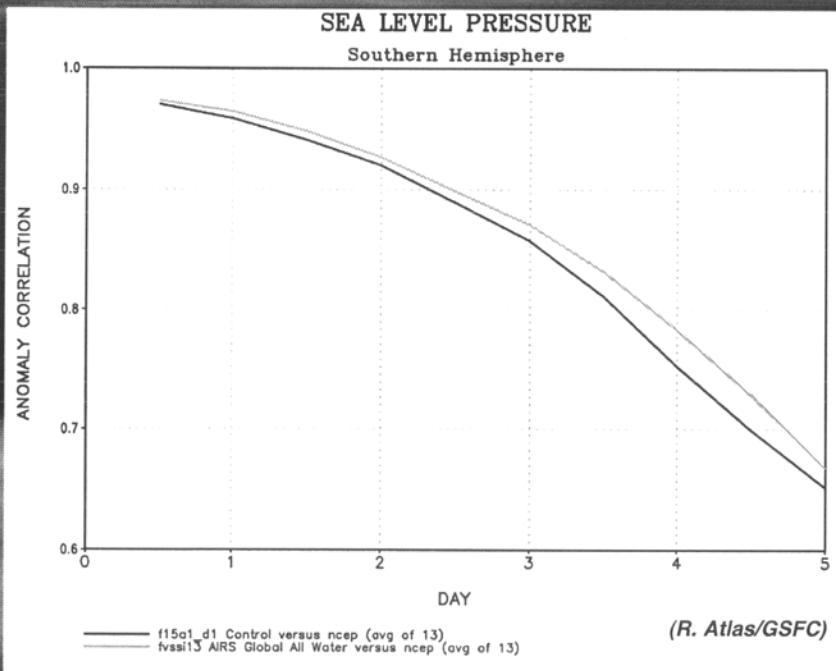
T. Pagano (JPL)



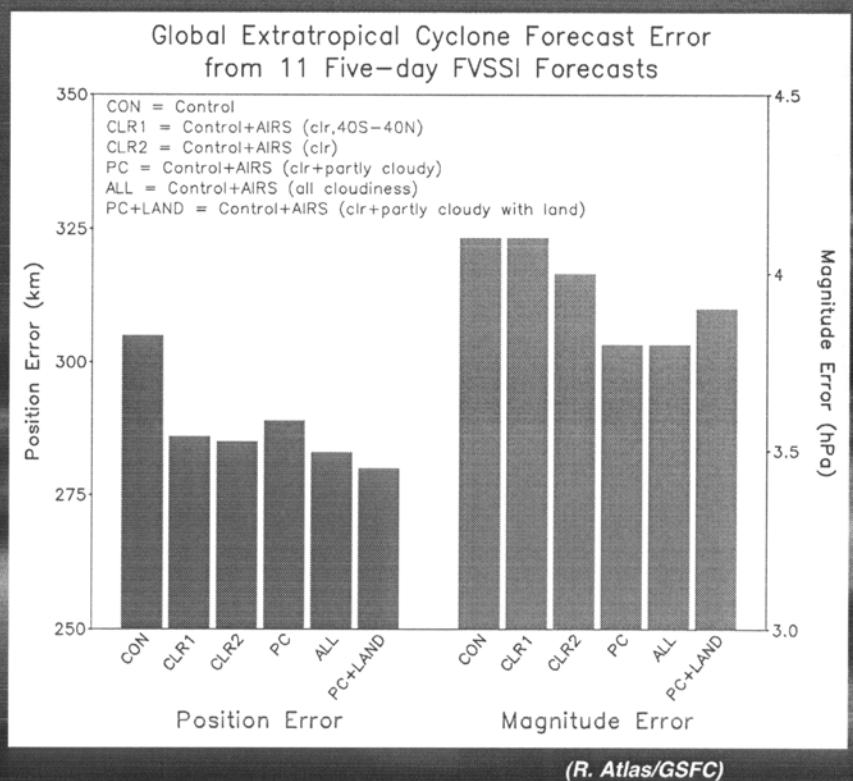
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Weather: Forecasts Impact

AIRS Improves 5 Day Forecast Score by 5-8 hours in SH



AIRS Reduces Cyclone Position and Magnitude Error Globally





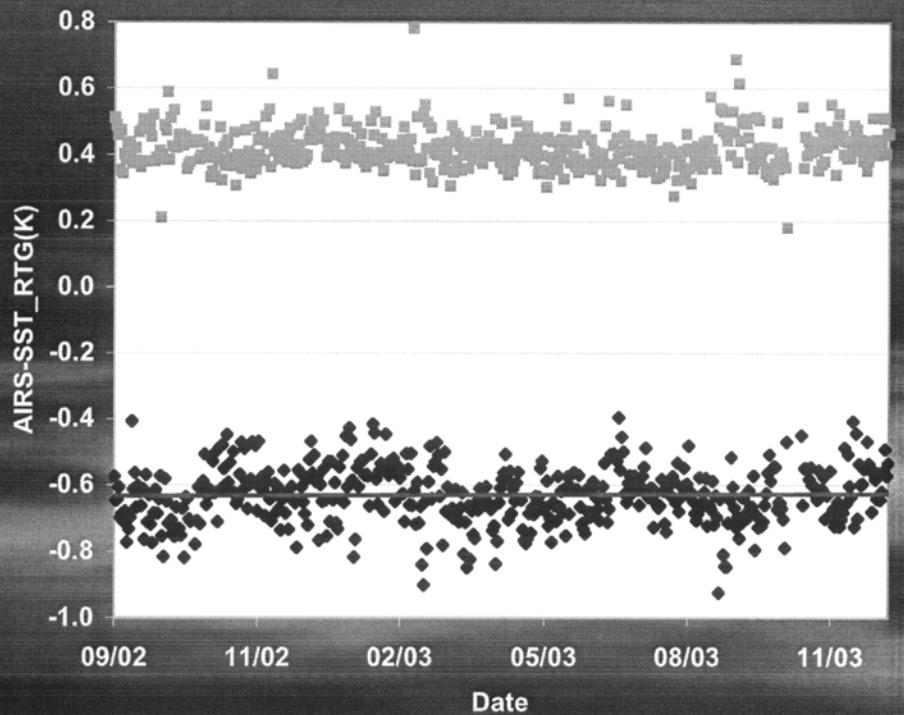
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Instrument Stability Allows Polarization to be Observable

- AIRS Stability Demonstrated using SST
 - (Aumann, SPIE 2004)
 - < 5 mK/Year Bias Drift
 - RMS Constant at 0.4K
- Same Observations Used for Overlap Channel Polarization
- Observations Considered
 - Clear Ocean Scenes
 - Day and Night Separately
 - One Month, 2003

AIRS Radiances Extremely Stable
Validated using RTG SST

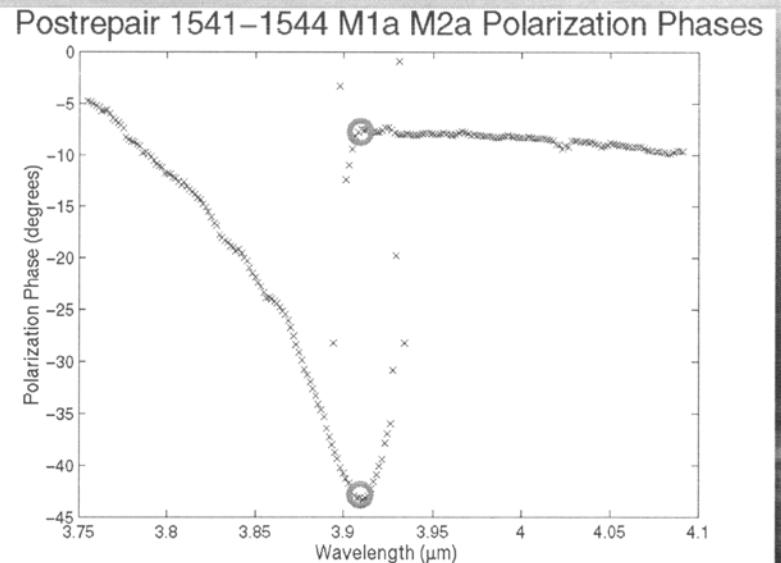
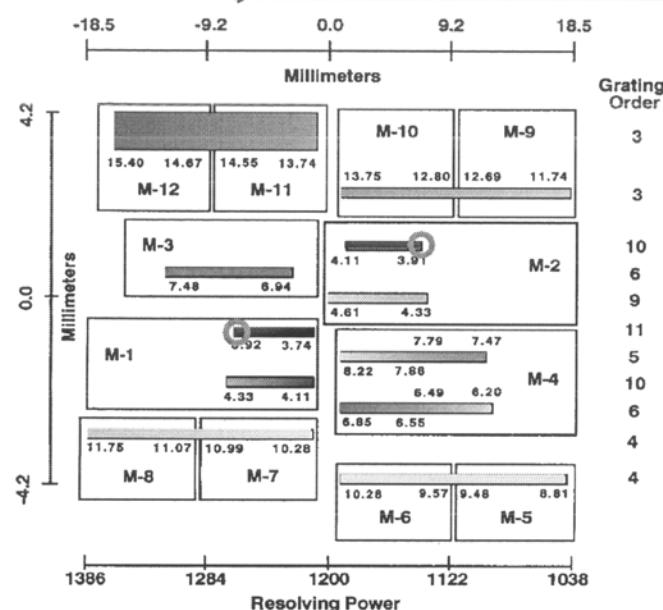




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AIRS Overlap Channels Have Different Polarization



Channel	2252	2280
Wavelength (microns)	3.9051	3.9045
Wavenumber (cm ⁻¹)	2560.8	2561.1
Scan Mirror Polarization	0.0031	0.0031
AIRS Polarization	0.1398	0.0200
AIRS Phase (deg)	-7.76	-43.2



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Expect Signal Difference in Overlap Channels if Scene Polarized

$$S = M_{sp} N_{sc}$$

$$M_{sp} = \frac{1}{2} \begin{bmatrix} q+r & (q-r)\cos 2\delta & (q-r)\sin 2\delta & 0 \\ (q-r)\cos 2\delta & (q+r)\cos^2 2\delta + 2\sqrt{(qr)}\sin^2 2\delta & (q+r-2\sqrt{(qr)})\sin 2\delta \cos 2\delta & 0 \\ (q-r)\sin 2\delta & (q+r-2\sqrt{(qr)})\sin 2\delta \cos 2\delta & (q+r)\sin^2 2\delta + 2\sqrt{(qr)}\cos^2 2\delta & 0 \\ 0 & 0 & 0 & 2\sqrt{(qr)} \end{bmatrix}$$

$$N_{sc} = \frac{1}{2} P_{sc} \begin{bmatrix} \varepsilon_s(\theta) + \varepsilon_p(\theta) \\ [\varepsilon_s(\theta) - \varepsilon_p(\theta)]\cos 2\theta \\ [\varepsilon_s(\theta) + \varepsilon_p(\theta)]\sin 2\theta \\ 0 \end{bmatrix}$$

$$S_o = S_{sc} - S_{sv} = N_{sc} K \tau \{ 1 + p_K p_t \cos 2(\theta - \delta) \}$$

$$p_K = \frac{\varepsilon_s - \varepsilon_p}{\varepsilon_s + \varepsilon_p} \quad p_t = \frac{q-r}{q+r} \quad K = \frac{\varepsilon_s + \varepsilon_p}{2} \quad \tau = \frac{q+r}{2} = 1$$

$$T_{err} = \frac{S_1 - S_2}{\partial N_{sc} / \partial T}$$

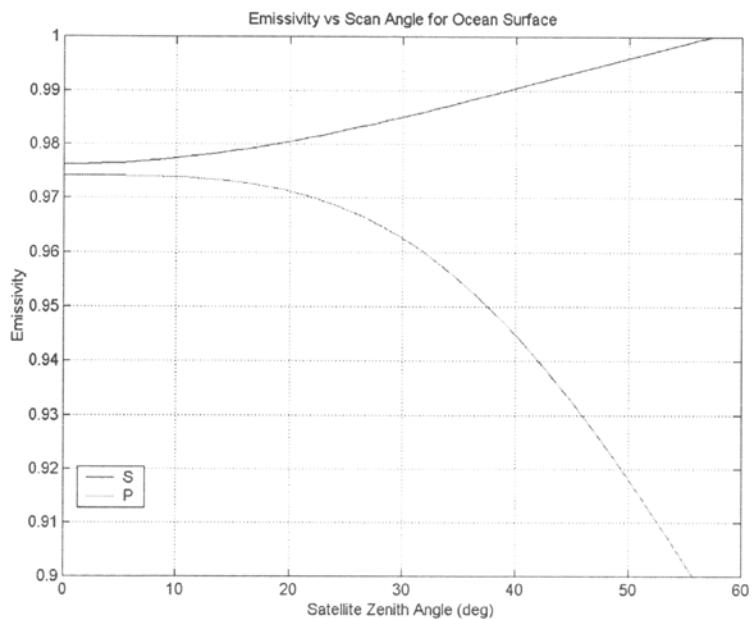


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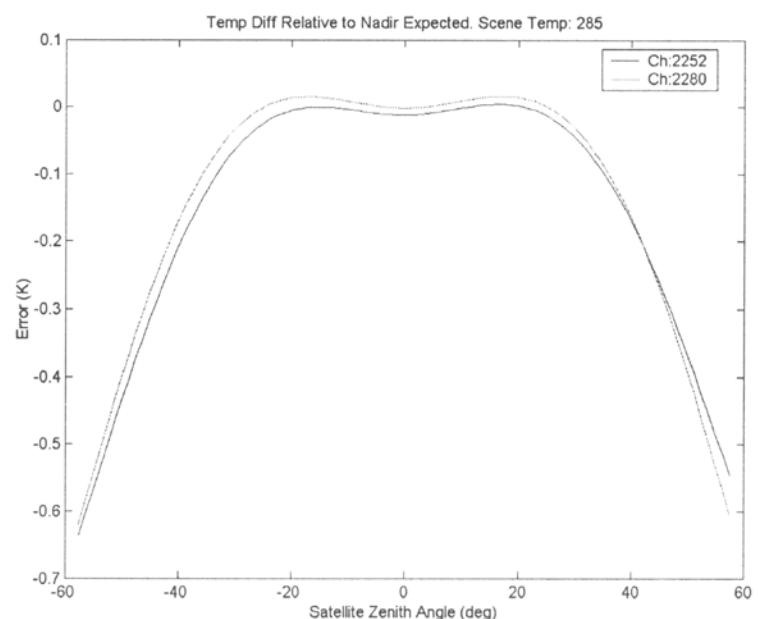
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Overlap Channels Respond Differently to Scene Polarization

S and P Emissivity of Water (Shaw, 2000)



Response of Each Overlap Channel

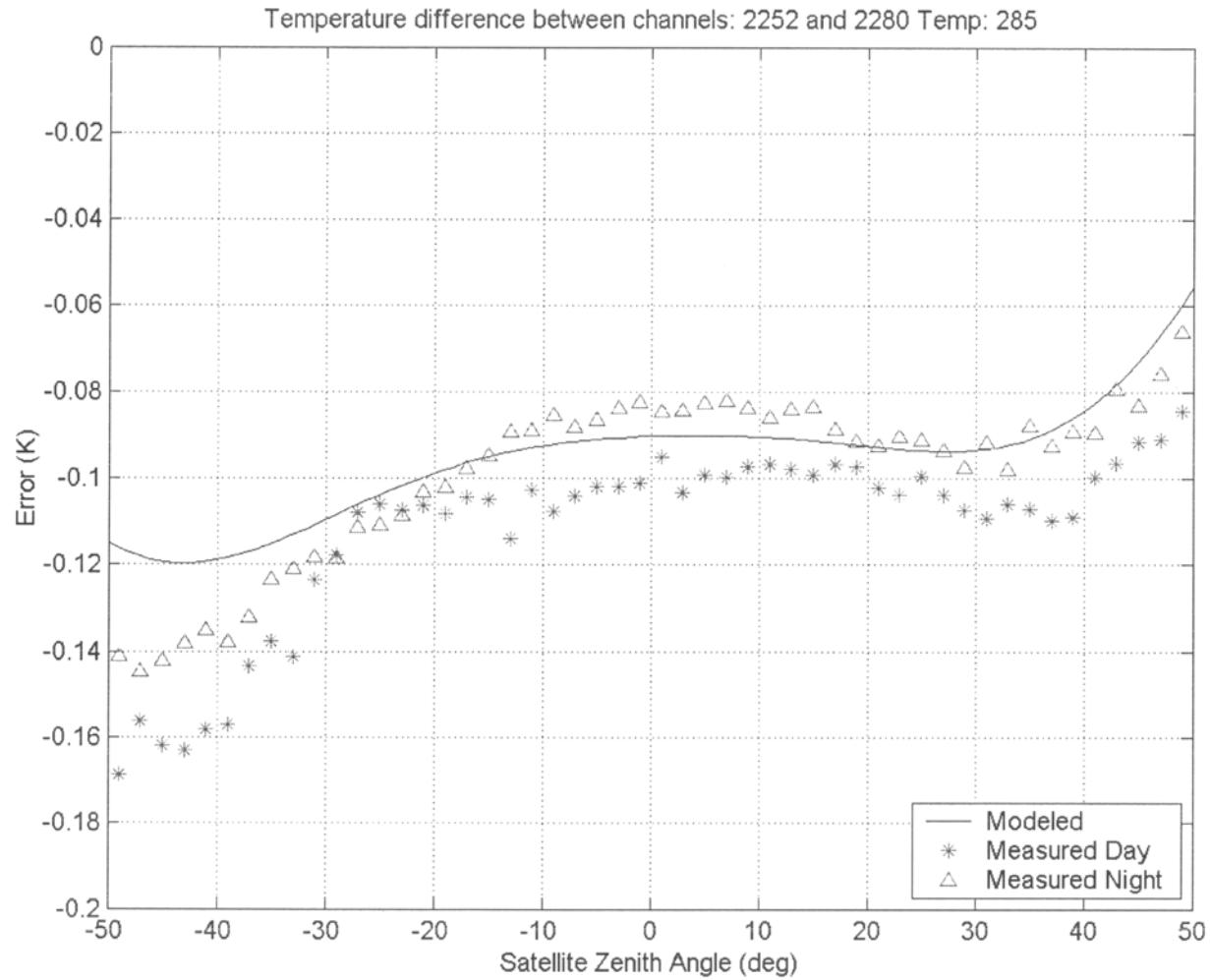




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Modeled Response to Ocean Polarized Radiance Matches Observations





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Summary and Conclusions

- Key AIRS Products Meet Requirements
- Stability Excellent
- Instrument Sensitive to IR Scene Polarization
- Response to Ocean Surface Polarization
Observed
- Compares well with expectations
- Negligible Impact to Radiometry
- For more information...



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<http://airs.jpl.nasa.gov>

AIRS – Atmospheric Infrared Sounder – Home

http://airs.jpl.nasa.gov/

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Daily Weather Maps from AIRS >>

Total Water Vapor Air Temperature Surface Temperature

MULTIMEDIA

SuperTyphoon Ponsogona Isotherms Hurricane Isabel, Sept 2003 Thermal Images

FEATURES

NASA's New Satellite Takes on Global Climate Change

Although there have been satellites measuring Earth's atmosphere since the 1970's, most have been designed for weather forecasting. Climate studies, which require the detection of subtle trends and changes that can take years to appear, require a new generation of spaceborne instruments. The Atmospheric Infrared Sounder, AIRS, flying on a NASA weather and climate research satellite called Aqua, is the first spaceborne instrument designed specifically to measure global climate change indicators. >>

New Global Maps Made from AIRS Data

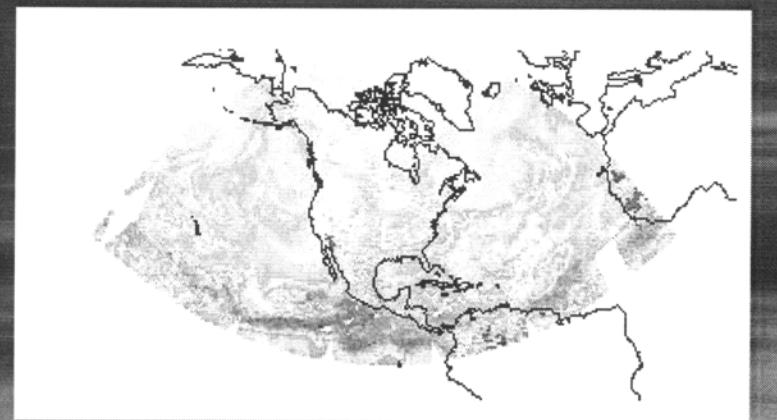
New images demonstrate the types of maps that can be made from AIRS data for researchers and forecasters. >>

Hurricane Isabel, AIRS Infrared and SeaWinds Scatterometer Data Combined

This image shows Isabel on September 13, 2003, when it was a Category 5 storm threatening the Caribbean and southern United States. >>

Maps of Total Water Vapor Over ConUS Provided Next Day after Acquisition

<http://airs.jpl.nasa.gov>



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